

NATURAL ABUNDANCE AND MOBILE FRACTIONS OF NANOPARTICLES IN SOILS

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RESEARCH OBJECTIVES

The current growing interest in nanomaterials and nanotechnology has stimulated the geoscience community to evaluate the roles of nanoparticle phenomena in many of the earth's natural processes. There is currently little quantitative information available on the abundance and mobility of nanoparticles in the subsurface. The importance of natural nanoparticles in facilitating chemical transport can only be evaluated based on knowledge of their inventories and mobility. The objective of this research is to address these two most basic questions: how abundant and how mobile are nanoparticles in the subsurface?

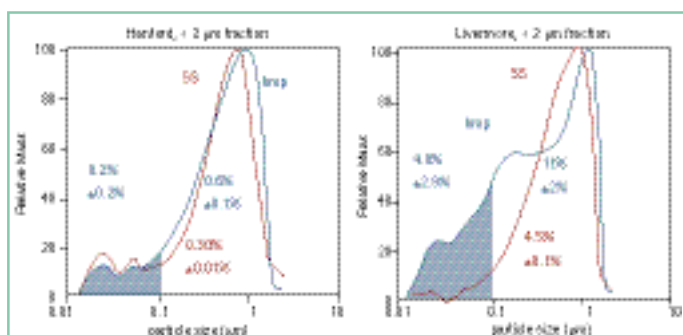


Figure 1. Examples of measured potentially mobile mass (red and $\leq 0.1 \mu\text{m}$) vs. mass of total colloid (including nanoparticle) inventory (blue shaded area). For the Hanford soil (pH 8.0), all the dispersible nanoparticle mass is potentially mobile. For the Livermore soil (pH 6.7), only a small fraction of the total dispersible nanoparticle inventory is potentially mobile.

APPROACH

To quantify the influences of soil properties on nanoparticle abundance and mobility, we collected representative types of soils from DOE facilities, including the Oak Ridge, Hanford, Livermore, and Savannah River Sites, all having different mineralogy, soil texture, and pH. Batch equilibrium and column-leaching experiments were conducted using two different kinds of solutions. One was Na-hexametaphosphate, a strong dispersing agent, used to obtain maximum particle releases, thereby defining the total inventories of nanoparticles. The other was a diluted soil pore solution, used to determine potentially mobile

fractions of nanoparticles. In these tests, nanoparticles were defined by an upper effective diameter of 100 nm.

ACCOMPLISHMENTS

We found that: (1) nanoparticles are ubiquitous in soils, and the inventories are proportional to their clay and organic matter fractions; (2) natural nanoparticles in soils consist primarily of common clay minerals and organic matter; and (3) the mobility of nanoparticles is highly pH dependent. No mobile fractions were detected in acidic soils, even when their total nanoparticle inventories were large.

SIGNIFICANCE OF FINDINGS

This research has provided the first survey of mobile nanoparticle inventories of sediments from a variety of subsurface environments. The finding that mobile nanoparticle fractions in natural acidic soils are practically undetectable is an important new insight for the environmental nanogeosciences. These studies will help constrain calculations of subsurface transport associated with nanoparticles.

RELATED PUBLICATIONS

- Wan, J., T.K. Tokunaga, E. Saiz, J.T. Larsen, Z. Zheng, and R.A. Couture, Colloid formation at waste plume fronts. *Environ. Sci. Technol.* 38, 6066–6073, 2004. Berkeley Lab Report LBNL-56059.
- Zheng, Z., J. Wan, and T.K. Tokunaga, Sodium meta-autunite colloids: Synthesis, characterization, and stability. *J. Colloid Interface Sci.* (in review), 2005. Berkeley Lab Report LBNL-54563.
- Wan, J., Z. Zheng, and T.K. Tokunaga, Natural abundance and mobile fractions of nanoparticles in soils. (Manuscript in Preparation, 2005).

ACKNOWLEDGMENTS

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